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Contract No. TBD
April 24, 2001

Mars Reconnaissance Orbiter

Orbiter Interface Roles and Responsibilities

EXHIBIT VI

Jet Propulsion Laboratory
California Institute of Technology

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1 Scope

This document is intended to extend and clarify the responsibilities listed in Article 1, Statement Of Work (SOW) by describing the Mars Reconnaissance Orbiter (MRO) Contractor's interface-related roles and responsibilities with other project elements elements [i.e., JPL project management and payload providers (for both science and engineering payloads), Deep Space Network, launch vehicle provider, mission design and mission operations]. It is recognized that there will be other more detailed technical interface documents negotiated with many of these project elements. The SOW takes precedence if there are any conflicts between this document and the SOW.

2 Orbiter-Payload Interface

2.1 Functions And Responsibilities Of Participating Organizations

The functions and responsibilities of each organization participating in the development and accommodation of the payload to Orbiter interfaces are defined below.

2.1.1 Orbiter Contractor

The Orbiter Contractor is responsible for integrating the payload onto the Orbiter and for providing compatibility with the approved Orbiter-payload Interface Control Documents (ICDs). The Orbiter Contractor is responsible for definition and coordination of the science and engineering payload interfaces with the payload representative(s) and JPL, development of comprehensive Orbiter-payload ICDs, integration of the science and engineering payloads per the ICDs, and leading the functional/interface testing of the Orbiter/payloads. The Orbiter Contractor will also:

1) Schedule, announce and conduct payload interface working group (IWG) meetings; record and disseminate minutes.

2) Develop and manage interface control processes and activities.

3) Incorporate a payload data management function into the Orbiter design.

4) Define interface/implementation requirements and constraints for each payload element and the Orbiter and document those requirements in the Orbiter-payload ICDs.

5) Define requirements for payload mechanical configuration, thermal and structural models to be provided by payload developers. Integrate the payload mechanical configuration, thermal and structural models into the Orbiter thermal and structural models. Provide as needed to the Payload Providers (PPs).

6) Update and maintain the Orbiter system thermal and structural/mechanical models.

7) Provide connectors to the PPs for incorporation into the payload interface(s).

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8) Provide environmental design/test data as needed to the payloads via the Environmental Requirements Document (ER-001) or other means mutually agreeable to the Orbiter Contractor and payload providers.

9) Lead the test of interfaces between the Orbiter and each science payload and engineering payload to verify that those interfaces are compatible with the overall Orbiter system design.

10) Provide analyses and/or test results to verify all of the interface requirements.

11) Prepare plans and procedures required for physically accomplishing and verifying the integration of the payloads.

12) Accomplish the electrical and mechanical integration of the payloads with the Orbiter, including supplying interface cabling and required mounting hardware as defined in the Orbiter-payload ICDs

13) Conduct and lead all interface integration and troubleshooting activities.

14) Provide test and/or analysis as necessary to isolate interface problems and to demonstrate interface compatibility.

15) Accomplish the thermal integration of the payload with the Orbiter, including ensuring thermal compatibility among payloads.

16) Provide control switching for replacement and supplemental payload heaters.

17) Prepare, using payload provider inputs, plans and procedures for evaluating payload engineering performance during system test.

18) Define requirements for interfaces between payload GSE and Orbiter GSE required for system testing of the Orbiter system

19) Provide cables between payload GSE and the Orbiter system test equipment as defined in the Orbiter/payload ICDs.

20) Witness payload thermal balance and pre-delivery tests.

21) Provide drawings showing Orbiter and payload fields of view (FOV) including solid angle FOVs and any FOV obscurations.

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22) Provide bonded stores and facilities to support payload receiving/acceptance and checkout consistent with the requirements contained in the payload ICDs.

2.1.2 JPL

JPL will support the payload-Orbiter interface development by providing appropriate technical representation and will review any actions to assure adherence to the project constraints. JPL's responsibilities are to:

1) Support preparation of payload-Orbiter integration plans and procedures.
2) Support the Orbiter-payload IWGs including the resolution of any interface related conflicts.
3) Approve payload-Orbiter ICDs.
4) Approve implementation of working group recommended Contract modifications that may:
   a) Result in changes in scope to the Orbiter Contractor
   b) Result in changes in scope to payload providers.
   c) Impact other MRO project elements by affecting interface compatibility, performance, risk, schedule, or cost.
5) Provide the payloads to the Orbiter Contractor consistent with the ICDs.

2.1.3 Payload Providers

The payload providers are responsible for leading the development of the science and engineering payloads and supporting the development of the Orbiter-payload interfaces. Responsibilities are to:

1) Provide technical representatives knowledgeable in the areas of payload engineering design and performance to support interface working group meetings and accommodation/interface definition activities.

2) Support definition of payload-Orbiter interfaces and implementation constraints, system level integration and test requirements and plans, and payload handling/storage environment monitoring at the Orbiter Contractor facility.

3) Provide inputs to the Orbiter Contractor for creation of payload integration and functional test procedures.

4) Incorporate the supplied electrical connectors, thermal control and other hardware into the payload design and hardware as specified in the payload-Orbiter ICD.

5) Provide payload data required for safety reviews and documentation.

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6) Develop the payload-related software and, as required, test equipment.

7) Provide test and/or analysis data sufficient to characterize and verify the performance of each payload prior to physical integration with the Orbiter including structural, thermal, and functional performance.

8) Develop and deliver to the MRO Project the science and engineering payloads that are compatible with the ICDs.

9) Provide payload GSE, GSE documentation, GSE maintenance, and stimuli required for Orbiter integration and system test.

10) Conduct payload pre-integration checkout after delivery to the integration site. Support acceptance inspection by the Orbiter Contractor.

11) Support integration of the payloads with the Orbiter.

12) Support tests on the integrated payloads to isolate integration problems.

13) Provide payload support during Orbiter system-level testing.

14) Provide payload command and telemetry data definitions required for Orbiter documentation.

15) Support evaluation of payload engineering performance during system test.

16) Provide fit check templates of payloads as required.

17) Provide analyses to support evaluation and accommodation of interface change requests.

18) Develop and provide payload mechanical configuration, thermal and structural models to support Orbiter Contractor system model development and related activities.

19) Provide payload interface simulators.

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3 Orbiter Telecommunications/DSN/GFP Interfaces

3.1 Functions And Responsibilities Of Participating Organizations

Specific functions and responsibilities of the Orbiter Contractor and JPL regarding the development and accommodation of the telecommunications subsystem.

3.1.1 Orbiter Contractor

The Orbiter Contractor shall have the leadership role in developing and maintaining these interfaces. The Contractor shall be responsible for administering interface working group meetings and achieving compatibility of all interfaces within the Orbiter telecommunication subsystem (including the JPL provided GFP), the support equipment, and the Deep Space Network (DSN). The Orbiter Contractor leads the planning, development, and verification/validation of these interfaces. The Orbiter Contractor's responsibilities are to:

1) Schedule, announce and conduct IWG meetings; record and disseminate minutes.

2) Develop and manage interface control activities.

3) Define and document Orbiter telecommunications subsystem interface requirements with the GFP telecommunications items (SDSTs, TWTAs) and associated GSE.

4) Participate in the SDST and TWTA MMRs, technical meetings and other meetings as necessary to fully understand the GFP hardware/software/GSE interfaces, performance characteristics and idiosyncrasies.

5) Plan, define and document the plans and procedures necessary to complete functional/acceptance testing of the SDSTs and TWTAs after delivery by JPL.

6) Define system test GSE interface requirements and implementation compatible with the telecom GSE equipment, and document those requirements in an appropriate ICD.

7) Assure the compatibility of the telecommunications subsystem interface to the DSN.

8) Provide the GSE to check out the telecommunications subsystem.

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9) Provide analyses and/or test results that are sufficient to validate all of the subject interface designs.

10) Identify and manage the resolution of all interface issues.

11) Prepare plans and procedures required for physically accomplishing and verifying the integration of the SDSTs and TWTAs into the telecommunications subsystem.

12) Lead and conduct all integration and troubleshooting activity.

13) Provide test and/or analyses necessary to isolate interface problems and to demonstrate interface compatibility.

14) Lead efforts to identify technical solutions to interface problems.

15) Accomplish the mechanical, electrical and thermal integration of the SDSTs and TWTAs with the telecommunications subsystem, including supplying all interface cabling and required mounting hardware between the SDSTS and TWTAs and the telecommunications subsystem.

16) Accomplish the telecommunications link analyses including identification and evaluation of all Orbiter telecommunications parameters (design values, measured values and tolerances) including RF transmitter power, path losses, modulation indices, coding definitions, data rates, frequency, timing stabilities and antenna patterns.

17) Participate with JPL in the conduct of the SDST flight acceptance tests at Motorola and, as needed, testing at JPL's Telecommunications Development Laboratory (TDL).

18) Provide Orbiter telecommunications subsystem hardware/software/GSE sufficient for demonstrating compatibility with the DSN using the DSN test trailer (CTT-21) at the Contractor's site and via MIL-71 at KSC.

19) Provide telecommunications test procedures and lead the conduct of the DSN compatibility tests both at the Contractor's site and at KSC.

3.1.2   JPL

JPL will support the interface development by providing appropriate technical representation for the Government Furnished Property (GFP) hardware and the DSN. JPL's responsibilities are to:

1)   Provide technical representatives from the areas of telecommunications systems engineering, Small Deep Space Transponders (SDSTs), Traveling

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Wave Tube Amplifiers (TWTAs), DSN engineering, and, as required, selected specialists.

2) Monitor and support the Orbiter Contractor's performance of the end-to-end telecommunications performance analysis as part of mission design efforts.

3) Provide the Small Deep Space Transponder (SDST) and documentation, as required, and the SDST GSE to support telecommunications subsystem and system testing.

4) Provide the TWTAs and documentation, as required, and the TWTA checkout equipment to support telecommunications subsystem and system testing.

5) Provide DSN performance parameters pertinent to the design of the telecommunications subsystem link functions of telemetry, command, and radiometric tracking.

6) Provide mission requirement data as necessary to support the definition of the telecommunications subsystem requirements and design.

7) Supply the DSN Compatibility Test Trailer (CTT-21) to the Contractor for testing at the Contractor's facility.

8) Support the DSN compatibility tests, accomplished via CTT-21 at the Contractor's site and via MIL-71 at KSC.

9) Obtain radio frequency assignment and authorization via the JPL Spectrum Manager.

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4 Launch Vehicle/Launch Site –Orbiter Interfaces

4.1 Introduction

The integration of the Mars Reconnaissance Orbiter (MRO) with the launch vehicle and the launch site is accomplished through activities of integration meetings (IMs). Organizations participating in the integration activities include JPL, KSC and their supporting Contractors.

4.2 Scope And Purpose Of Integration Meetings

The integration meetings are the means by which the MRO Orbiter, launch vehicle and launch site integration is managed, coordinated, scheduled and controlled. The scope of the integration activities associated with these meetings include:

1) Identifying and establishing Orbiter/launch vehicle physical, functional and environmental requirements and verification and validation requirements.

2) Interchanging mission, Orbiter, and launch vehicle system technical information for the development and analysis of the launch vehicle performance including, but not limited to coupled loads, launch period and windows, launch trajectories, and guidance and control through Orbiter injection.

3) Identifying and establishing Orbiter requirements for launch site facilities, communications, storage, logistics and support for all operations at the launch site from Orbiter arrival through launch and Orbiter checkout.

The integration meetings are scheduled quarterly, typically alternating locations between JPL, KSC, the Orbiter Contractor and launch vehicle Contractor. Technical interchange meetings and telecons are scheduled as required to address focused technical issues

4.3 Functions And Responsibilities Of Participating Organizations

4.3.1 Orbiter Contractor

The Orbiter Contractor will support the project/launch vehicle system integration activities. Responsibilities are to:

1) Support the telecons, IMs and TIMs.

2) Provide information such as mass properties and finite element models, and perform analyses as necessary for the electrical, mechanical and environmental interface verification process with the launch vehicle.

3) Prepare and submit the Orbiter and Orbiter/launch vehicle interface safety data to KSC.

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4) Implement the interface requirements into the Orbiter design.

5) Provide test and/or analytical data to verify that the interface design meets the requirements in the launch vehicle/MRO Mission Specification (ICD).

6) Support integrated interface verification testing.

7) Provide the Orbiter launch site processing requirements and support functional and physical integration.

8) Perform all required Orbiter preparations for launch vehicle integration including Orbiter propellant loading, and launch complex support equipment integration and verification prior to Orbiter integration with the launch vehicle.

9) Support launch team training, including integrated launch day dress rehearsal tests.

10) Provide the Orbiter launch operations requirements and support launch operations.

4.3.2   JPL

1) Participate in the telecons, integration meetings and the TIMs.

2) Provide Project management direction to the Orbiter Contractor, KSC and the payload suppliers in the launch vehicle interface definition and integration effort.

3) Provide payload safety data information to the Orbiter Contractor.

4) Provide inputs to the launch vehicle/MRO Mission Specification (ICD).

5) Report on safety status and issues at the integration meetings.

6) Produce, maintain, and provide configuration control of the MRO Launch Vehicle System Requirements document.

7) Provide propellant and pressurizing agents.

4.3.3   Kennedy Space Center

1)   Provide LV Mission Management.
2)   Provide technical oversight of the launch vehicle.

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3) Provide Management of mission integration.
4) Provide oversight of the launch vehicle processing and NASA launch-day management.
5) Provide payload processing support, processing facilities and payload range services.
6) Provide operations and communications facilities support for launch operations.
7) Develop and document the stand-alone Orbiter Program Requirements Document (PRD) and the Launch Site Support Plan (LSSP).
8) Lead the MRO/launch vehicle telecons, integration meetings and the TIMs.
9) Procure the MRO launch vehicle and launch services
10) Support launch team training, including integrated launch day dress rehearsal tests.

4.3.4   Launch Vehicle Contractor

1) Support the activities of the integration meetings and TIMs.
2) Provide MRO Launch Vehicle.
3) Prepare the launch vehicle/MRO Mission Specification (ICD) and other required documentation.
4) Implement mission unique interface requirements into the launch vehicle.
5) Provide launch vehicle integration hardware including the Payload Adapter Fitting (PAF) and associated hardware including adapter cabling to the Orbiter field joint.
6) Lead the physical integration of the Orbiter with the launch vehicle.
7) Prepare the launch vehicle for launch and support launch operations.

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5 Mission Design – Orbiter Interface

5.1 Mission Design and Navigation Team (MDT)

The mission design team (MDT) is responsible for the analysis and design of the Mars Reconnaissance Orbiter mission.

5.1.1 Organization

The MDT will be chaired by the JPL mission design manager. The team will be staffed by representatives from the Orbiter Contractor, JPL, and the Payload Providers. KSC and the launch vehicle Contractor provide launch vehicle interface support to the mission design effort through the Integration Meetings.

5.1.2 Responsibilities

The mission design team responsibilities are to:

1) Define the mission and navigation requirements and constraints.

2) Analyze mission scenarios and define a mission plan and a navigation plan.

3) Analyze the project's compliance with the planetary protection program.

4) Support design reviews.

5) Establish and maintain MDT interface and working agreements.

6) Establish meeting agendas, schedules, and action items.

7) Coordinate mission design activities with the integration meetings.

8) Establish navigation predicts and maneuver design requirements.

5.2 Functions And Responsibilities Of Participating Organizations

Specific functions and responsibilities of the Orbiter Contractor, JPL, the PPs, and KSC are defined below.

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5.2.1 Orbiter Contractor

The Orbiter Contractor shall support the mission and navigation design activities. Specific responsibilities are to:

1)   Provide continuous mission and navigation design support with regular attendance (or by teleconference) at MDT meetings, or through regularly scheduled technical interchange meetings.

2)   Provide inputs to the Mission Plan.

3)   Support the mission scenario development of the orbit insertion phase. Provide inputs to aerobraking scenarios.

4)   Provide inputs to the Navigation Plan.   Some specific quantities are given below.   These quantities are required during development and preparatory to mission operations.   Accuracy estimates and algorithms used in deriving these quantities are also required.

   a)   Orbiter mass and center of mass

   b)   Propulsion maneuver parameters and execution uncertainties

   c)   Solar radiation pressure parameters, including Orbiter component dimensions (drawings with dimensions) and reflectivity coefficients and other non-gravitational forces.

   d)   Orbiter self-generated acceleration estimates such as angular momentum durations

5)   Supply AMD predict data.

6)   Provide engineering sequence inputs for maneuver designs based on MDT's requirements.

   Individuals providing MDT support shall be knowledgeable in the mission design process and be able to provide the pertinent Orbiter performance parameters.

5.2.2   JPL

JPL will lead the mission design. Specific responsibilities are to:

1)   Chair the MDT, announce and conduct meetings, record and disseminate minutes, and assign and monitor action items.

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2) Prepare and maintain the mission requirements document, which defines the requirements for mission design and planning, defines the mission constraints, and places requirements on the mission and the project systems.

3) Analyze and design mission scenarios including aerobraking. Define a baseline mission design and document it in the mission plan and navigation plan.

4) Lead the trajectory and orbit design of all mission phases: interplanetary cruise, orbit insertion and mapping. Ensure that these designs satisfy the mission requirements and are compatible with Orbiter capabilities. Document the designs in the trajectory characteristics document.

5) Analyze the mission mass performance and summarize the status in a periodic performance assessment report.

6) Define the launch vehicle targeting requirements and document them in the target specification. Analyze and define the launch performance constraints and document them in the launch period utilization report.

7) Analyze the project's compliance with the NASA planetary protection program.

8) Provide the mission design and mission planning software required.

9) Provide any necessary prelaunch trajectory data required by other project design teams.

10) Provide planetary constants and models for other project design teams.

11) Prepare the DSN initial acquisition geometry report.

12) Prepare mission contingency plans.

5.2.3   Payload Providers

The PPs provide support in the mission design effort. Specific responsibilities are to:

1) Provide technical representatives to the MDT knowledgeable in the scientific objectives and the payloads' operation and constraints.

2) Support mission design reviews.

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6   Mission Operations System – Orbiter Interface

6.1   Functions and Responsibilities of Participating Organizations

The functions and responsibilities of each organization participating in the development of the Mission Operations System/Ground Data System (MOS/GDS) and operating the Orbiter are defined below.

6.1.1 Orbiter Contractor

The Orbiter Contractor shall provide support to the MOS/GDS development, test and operations phases. Specific responsibilities include:

1) Actively participate in MOS/GDS design and development activities.
2) Provide requirements to the Orbiter testbed and other required operational capabilities.
3) Develop Orbiter related MOS/GDS specifications, procedures and plans.
4) Review and provide comments to MOS/GDS related documents.
5) Prepare and participate in MOS/GDS reviews.
6) Coordinate with the payload providers to identify engineering telemetry, and alarm limits needed to assess payload performance during system testing and operations.
7) Participating with JPL and PPs to prepare and review flight sequences for Orbiter system tests and flight sequence developed pre-launch.
8) Support the MOS/GDS to Orbiter compatibility tests and be the focal point for interfaces with ATLO personnel (Orbiter Contractor provides most of the ATLO personnel.)
9) Participate in related MOS/GDS test and training activities.
10) Provide systems and subsystems expertise in operating the Orbiter.
11) Provide flight software maintenance expertise during the operations.
12) Support Project System Engineering in conducting an end-to-end information system analysis.
13) Support the development of the DSN initial acquisition plan.
14) Support development of risk assessments for flight operations with corresponding mitigation plans.
15) Generation of the launch sequence.

6.1.2   JPL

JPL will lead the MOS/GDS development and operations phases. JPL's responsibilities are to:

1) Lead MOS/GDS design activities.
2) Plan, prepare and coordinate the MOS/GDS development and implementation.

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3) Identify and coordinate MOS/GDS design documentation.
4) Prepare the DSN initial acquisition plan.
5) Plan, prepare and coordinate the conduct of the MOS/GDS integration, test and training.
6) Plan, prepare and coordinate pre-launch flight sequence development, test and verification/validation.
7) Plan, prepare and coordinate the Orbiter-to-MOS/GDS compatibility testing.
8) Provide all telemetry, tracking, navigation and command processing required to support the Orbiter during mission operations.
9) Lead the flight operations activities.
10) Lead Project Systems Engineering and risk assessments with mitigation plans.

6.1.3   Payload Providers

The PPs are responsible for leading the development of the instrument operational scenarios, command sequences, and assessing instrument performance during mission operations.

1) Actively participate in MOS/GDS design and development activities including attending bi-monthly face-to-face meeting at JPL and weekly design team telecon.
2) Provide requirements to the Orbiter testbed and other operations required capabilities.
3) Develop instrument related MOS/GDS specifications, procedures and plans.
4) Review and comment on MOS/GDS related documents.
5) Prepare and participate MOS/GDS reviews.
6) Participate with JPL and Orbiter Contractor to prepare flight sequences for Orbiter system test
7) Establish required housekeeping telemetry and alarm limits for monitoring instrument health during operations.
8) Support the MOS/GDS-to-Orbiter compatibility tests
9) Participate in related MOS/GDS test and training activities.
10) Provide instrument expertise in operation.
11) Provide instrument flight software maintenance expertise during the operations.